Report for 2001HI701B: Removal of Nitrogeous Aquaculture Wastes by a Wind-Powered Reverse Osmosis System

- Articles in Refereed Scientific Journals:
  - Liu, C.C.K.; J.W. Park; J. Migita; G. Qing, Experiments of a prototype wind-driven reverse osmosis desalination system for Pacific islands, Journal of Desalination, under review.

Report Follows:

Problem and Research Objectives

Advanced treatment must be provided to wastewater used for freshwater aquaculture in order to meet effluent water quality standards. Because such treatment can be expensive and because freshwater is also increasingly in short supply around the world, an attractive management alternative is to develop a closed aquaculture system that supports effluent treatment and reuse while overcoming obstacles of high treatment cost and a short freshwater supply. The research objectives are (1) to investigate the nitrogen build-up in freshwater aquaculture of tilapia, (2) to develop a wind-powered reverse osmosis nitrogen removal system, and (3) to evaluate the economic feasibility of the wind-powered reverse osmosis system for removing nitrogen from aquaculture wastes.

Methodology

This is a two-phase project, with each phase lasting about one year. The focus of the first year's research (activities and findings reported here) is to study the characteristics of aquaculture waste, especially the concentration of nitrogen at different stages of fish (tilapia) growth. The second year's research will be conducted to investigate the performance of nitrogen removal by the reverse osmosis process and to develop a water recirculating system for tilapia production.

Principal Findings and Significance

An experimental system, which consists of an aquaculture subsystem or a fish tank for tilapia culture and a wind-powered reverse osmosis treatment subsystem, was constructed at the research facilities of the Hawaii Institute of Marine Biology on Coconut Island, Oahu, Hawaii.

Water samples were collected from the tilapia culture tank from June 2001 to February 2002. Samples were analyzed in the water quality laboratory of the Water Resources Research Center at the University of Hawaii at Manoa. Table 1 shows the nitrogen concentration data for the aquaculture subsystem. Feedwater is the freshwater provided to the fish tank. Discharge indicates the aquaculture waste flow out of the fish tank. The waste discharge

Table 1. Nitrogen Concentrations of Aquaculture Subsystem Under Normal Conditions

Date	NH_3-N (mg/l)		NO_3-N (mg/l)		NO_2-N (mg/l)	
	Feedwater	Discharge	Feedwater	Discharge	Feedwater	Discharge
06/13/2001	UD*	0.19	0.17	0.14	0.001	0.006
06/14/2001	UD	0.14	0.17	0.14	0	0.001
06/15/2001	UD	0.11	0.21	0.17	0.003	0.004
06/21/2001	UD	0.12	0.20	0.16	0.003	0.002
07/10/2001	UD	0.07	0.15	0.13	0.002	0.001
01/07/2002	UD	0.40	0.17	0.17	0.001	0.001
01/09/2002	UD	0.32	0.17	0.17	0.001	0.003
01/17/2002	UD	0.50	0.16	0.16	0	0
01/22/2002	UD	0.23	0.17	0.20	0	0.001
01/24/2002	UD	0.20	0.17	0.18	0.001	0.002
01/31/2002	UD	0.09	0.17	0.17	0.002	0.001
02/05/2002	UD	0.22	0.14	0.16	0	0.001
02/12/2002	UD	0.26	0.16	0.16	0.001	0.002
02/14/2002	UD	0.06	0.18	0.16	0	0.002
02/21/2002	UD	0.09	0.14	0.14	0	0
02/26/2002	UD	0.25	0.12	0.12	0.004	0.003

*****UD = undetectable.

becomes the feedwater for the wind-powered reverse osmosis treatment subsystem. The hydraulic retention time in the aquaculture subsystem or fish tank was about 500 minutes (8.3 hours). During this time, the feedwater and waste discharge rates were both about 73 gal/h (4.6 l/min).

The feedwater provided to the fish tank contained ammonia nitrogen (NH_3-N) at a concentration of less than 0.03 mg/l, whereas the concentration in the aquaculture waste discharge averaged 0.20 mg/l with an unbiased standard deviation of ±0.12 mg/l. The average feedwater nitrate nitrogen (NO_3-N) concentration was 0.17 ± 0.02 mg/l, and the discharge concentration was 0.16 ± 0.02 mg/l. The nitrite nitrogen (NO_2-N) concentration was 0.0012 ± 0.0012 mg/l for the feedwater and 0.0019 ± 0.0015 mg/l for the discharge.

Performance of the reverse osmosis treatment subsystem to remove nitrogen has been evaluated by studying nitrogen concentrations in the feedwater and product water (permeate), as well as by studying the operating flow rate and feed water pressure. Preliminary data indicated that the subsystem removes about 93% of the ammonia and nitrate from the feedwater. The effluent from the treatment subsystem, with very low concentrations of nitrogen, would be suitable for reuse in tilapia culture.

A paper, “Experiments of a prototype wind-driven reverse osmosis desalination system for Pacific islands,” by C.C.K. Liu, J.W. Park, J. Migita, and G. Qing has been submitted to the *Journal of Desalination.* It is currently under review.

The second phase of this project began in March 2002.